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[Title of the Invention] Process for producing aluminum alloy soft material for welded structure

[Summary] To produce an Al-Zn-Mg alloy soft material for a welded structure having excellent cold workability.

[Constitution] A method comprising hot working an Al alloy containing 3 to 8% of Zn, 0.5 to 3.0% of Mg and 0.01 to 0.5% of Cu and furthermore one or more of 0.005-0.30% of Ti, 0.05 to 0.7% of Mn, 0.01 to 0.5% of Cr, 0.05 to 0.30% of Zr and 0.01 to 0.1% of V, thereafter holding the resulting alloy under heating at 180 to 320°C for 0.5 to 24 hours and then cooling the heated alloy to room temperature.

[Effect] An Al-Zn-Mg alloy for a welded structure having reduced change with time due to aging at room temperature and excellent cold workability can be obtained.

[Claim]

[Claim 1] A process for producing a soft aluminum alloy material for a welded structure comprises subjecting an aluminum alloy containing, on a weight basis, 3 to 8% of Zn, 0.5 to 3.0% of Mg and 0.01 to 0.5% of Cu and at least one kind of 0.005 to 0.30% of Ti, 0.05 to 0.7% of Mn, 0.01 to 0.5% of Cr, 0.05 to 0.30% of Zr and 0.01 to 0.15% of V, the balance being Al and impurities to hot working with the use of a normal production step, thereafter holding the obtained alloy under heating at a temperature of 180 to 320°C for 0.5 to 24 hours as a softening treatment and thereafter cooling the resulting alloy to room temperature.

[Detailed Explanation of the Invention]

[0001]

[Industrially Applicable Field] The present invention relates to a process for producing an Al-Zn-Mg based alloy soft material for welded structures.

[0002]

[Prior Art Technique] A representative Al-Zn-Mg based alloy soft material for welded structures is JIS-7N01 alloy, and as the annealing conditions for this alloy, a method comprising heating an alloy up to 450°C and thereafter cooling the heated alloy in an oven or a method comprising holding the alloy under heating at 410 to 430°C for 2 hours, thereafter cooling the heated alloy in the air, then heating the obtained alloy again to about 330°C, holding the alloy at this temperature for about 4 hours and thereafter cooling the resulting alloy to room temperature is recommended.

[0003]

[Problem to Be Solved by the Invention] However, the former method allows the solute component to form a supersaturated solid solution even when as the cooling conditions, cooling in an oven is taken, and by leaving the alloy after cooling to stand at room temperature, age hardening is caused to the deterioration of cold workability of the soft material. Further, the latter method has to perform heat treatment twice and is attended with complicatedness. The present invention is to improve these points.

[0004]

[Means to Solve the Problem] The present invention is a process for producing an aluminum alloy soft material for a welded structure comprising subjecting an aluminum alloy containing 3 to 8% of Zn, 0.5 to 3.0% of Mg and 0.01 to 0.5% of Cu and at least one kind of 0.005 to 0.30% of Ti, 0.05 to 0.7% of Mn, 0.01 to 0.5% of Cr, 0.05 to 0.30% of Zr and 0.01 to 0.15% of V, the balance being Al and impurities to hot working with the use of a normal production step, thereafter holding the obtained alloy under heating at a temperature of 180 to 320°C for 0.5 to 24 hours as a softening treatment and thereafter

cooling the resulting alloy to room temperature.

[0005] In the present invention, by setting the softening treatment after hot working at the above described ranges, an alloy component is deposited by a once-off heat treatment to reduce the amount of solid solution in the mother phase and the flow stress in the cold is decreased by agglomerating/coarsening the deposited particles, and age hardening on being left to stand at room temperature is inhibited.

[0006] The reason for limiting the alloy composition is as follows.

Zn: To increase strength at room temperature. With amounts of less than 3%, high strength cannot be obtained in T4 or T6 material and with amounts of more than 8%, stress corrosion cracking is easily caused.

Mg: To increase strength at room temperature. With amounts of less than 0.5%, high strength cannot be obtained in a T4 or T6 material and with amounts of 3%, stress corrosion cracking is easily caused.

[0007] Cu: To improve stress corrosion cracking. With amounts of less than 0.01%, its effect is small and with amounts of more than 0.5%, its improving effect is saturated and the deterioration of weldability is caused.

Ti: To have an effect for making a cast structure fine and preventing cracking of an ingot. With amounts of less than 0.005%, no effect is found and with amounts of more than 30%, a giant intermetallic compound is unfavorably crystallized.

Mn, Cr, Zr, V: These elements have an effect of rendering crystal grains fine. Coarsening of crystal grains causes surface roughening on cold working such as bending. These elements also improve stress corrosion cracking resistance. This effect is small when added in amounts of less than the lower limits and with amounts of more than the upper limits, a giant crystallized product is unfavorably formed on DC casting typically employed industrially.

[0008] Further, "impurities" means Fe and Si in this case. The material which is applied to softening treatment in the

present invention is limited to a hot worked material itself such as a hot rolled material and a hot extruded material. The reason is that viewed from the metallographic structure, the soft material needs to be in a recovered or recrystallized state and the material undergone hot working has this structure.

[0009] The softening treatment of the present invention has an object to deposit, agglomerate and coarsen solid solution components (mainly Zn and Mg) in the mother phase in the form of particles. When the deposition is insufficient, the mother phase is solid solution-strengthened by the solid solution components and the flow stress is raised during cold working. Further, when the material is stored at room temperature for a long time as stock, proof stress and tensile strength are increased by age hardening and elongation is decreased. Furthermore, since the flow stress becomes small, the deposited particles have to be adjusted in the range of 0.01 to 10 µm by agglomeration/coarsening. On account of this, the holding condition under heating on softening treatment has to be 0.5 to 24 hours at a temperature of 180 to 320°C. At temperatures of lower than 180°C, the solid solution components cannot be fully deposited unless held for a long period of time and such long-term holding is economically disadvantageous. At temperatures of higher than 320°C, re-solid solution of alloy components is invited and even if cooling from this temperature at rate of not higher than 30°C/h is performed, the deposition of supersaturated solid solution components becomes insufficient and the tensile strength is increased due to age hardening caused even with the low tensile strength immediately after softening in the case of leaving the material after cooling to stand at room temperature. With holding times of shorter than 0.5 hour, it is impossible to deposit, agglomerate and coarsen the alloy components. Holding for longer than 24 hours is not only economically disadvantageous but also brings about excess grain boundary deposition to lower ductility.

[0010] When the heating temperature region is higher than 250°C up to 320°C, the cooling rate is preferably 30°C/h. When the cooling rate is high, a difference between the solid

solution limit of the alloy elements in this temperature region and that in the temperature region of not higher than 250°C comes to a supersaturation to form solid solution. This might bring about age hardening at room temperature. When cooling is performed at a rate of not higher than 30°C/h down to the temperature range of not higher than 250°C, the supersaturated content can be fully deposited to cause no problem. Further, when the holding temperature under heating is from a temperature of not higher than 250°C, the age hardening at room temperature has no problem independently of the cooling rate.

[0011]

[Example] The alloy shown in Table 1 was made into a 30 mm (thick)×200 mm (wide)×200 mm (long) ingot and then the ingot was subjected to homogenization treatment at 460°C for 12 hours. This ingot was made into a 2 mm-thick plate by hot rolling from 450°C. This hot rolled plate was annealed with the use of the conditions shown in Table 2 and various evaluations were made.

[0012] In Table 3, an alloy having a tensile strength of not more than 250 MPa and an elongation of not less than 20% as mechanical properties immediately after softening treatment was judged as an accepted product (○) as the criterion for cold workability. Further, in order to examine how the mechanical properties changed by age hardening in storage at room temperature, the mechanical properties of the alloy which had been left to stand for 90 days after softening was examined. An alloy having an increased tensile strength by not more than 15 MPa compared to the tensile strength immediately after softening was judged as an accepted product (○). On the supposition of use in the site requiring strength for a welded structure, the softened material was subjected to T6 treatment and thereafter the strength was examined. As the T6 conditions, the softened material was held at 460°C for one hour, thereafter cooled with water and tempered at 120°C for 24 hours. The obtained material having a tensile strength of not less than

350 MPa was judged as an accepted product (○). Next, the stress corrosion cracking test of the T6 material was carried out. In accordance with JIS H8711, with the use of a 1B test sample under a load of 196 MPa, alternate dipping in a 3.5% NaCl aqueous solution was performed for 30 days. After completion of the 30-day test, the sample having no cracking formed was judged as an accepted product (○).

[0013] Table 1

Alloy		Zn	Mg	Cu	Ti	Mn	Cr	Zr	V
Examples of the Present Invention	A	4.0	2.0	0.15	0.02	-	-	-	-
	B	4.1	2.1	0.17	-	0.35	-	-	-
	C	4.4	2.0	0.18	-	-	0.15	-	-
	D	4.2	2.3	0.20	-	-	-	0.18	-
	E	4.5	2.0	0.17	-	-	-	-	0.07
	F	6.2	2.0	0.14	0.02	0.10	0.12	-	-
	G	6.4	2.1	0.16	0.02	-	-	0.15	0.05
Comparative Examples	H	9.5	2.0	0.15	0.02	-	-	0.18	-
	I	2.2	2.0	0.15	0.02	-	-	0.17	-
	J	4.5	0.2	0.16	0.02	-	-	0.17	-
	K	4.2	2.2	-	0.02	-	-	0.18	-
	L	4.0	2.1	0.16	-	-	-	-	-

Note: wt.%, the balance being Al and impurities

[0014] Table 2

	Conditions	
	Temperature (°C)	Holding Time (h)
1 (Example of the present Invention)	210	12
2 (Example of the present Invention)	280	6
3 (Example of the present Invention)	320	2
4 (Comparative Example)	150	24
5 (Comparative Example)	350	1

[0015] Table 3

	Alloy	Heat Treatment	Immediately After Softening			Left to Stand at Room Temperature for 90 Days after Softening		
			Tensile Strength MPa	Elongation (%)	Judgment	Tensile Strength MPa	Difference (MPa) in Tensile Strength from Immediately after Softening	Judgment
Examples of the Present Invention	A	1	233	24	○	238	5	○
	B	1	239	25	○	239	0	○
	C	2	221	25	○	223	2	○
	D	2	213	25	○	220	7	○
	E	2	220	25	○	232	12	○
	F	3	240	26	○	246	6	○
	G	3	244	23	○	250	6	○

	H	2	249	23	○	258	9	○
	I	2	195	28	○	203	8	○
	J	2	180	30	○	183	3	○
Comparative Examples	K	2	210	26	○	217	7	○
	L	2	225	26	○	226	1	○
	A	4	322	17	×	325	3	○
	D	5	218	25	○	252	34	×
	H	5	243	24	○	290	47	×

Table 3 (-continued)

	Alloy	Heat Treatment	After T6 Treatment		Test for Stress Corrosion Cracking
			Tensile Strength MPa	Judgment	
Examples of The Present Invention	A	1	370	○	○
	B	1	375	○	○
	C	2	372	○	○
	D	2	368	○	○
	E	2	372	○	○
	F	3	392	○	○
	G	3	398	○	○

Comparative Examples	H	2	405	○	×
	I	2	312	×	○
	J	2	280	×	○
	K	2	355	○	×
	L	2	370	○	×
	A	4	368	○	○
	D	5	372	○	○
	H	5	415	○	×

[0016]

[Effect of the Invention] According to the present invention, an alloy for a welded structure whose flow stress in cold working is decreased by a once-off heat treatment and age hardening on being left to stand at room temperature is inhibited can be obtained.